Effect of Degree of Phosphorylation on Electrospinning and In vitro Cell Behavior of Phosphorylated Polymers as Biomimetic Materials for Tissue Engineering Applications

Authors : Pallab Datta, Jyotirmoy Chatterjee, Santanu Dhara

Abstract : Over the past few years, phosphorous containing polymers have received widespread attention for applications such as high performance optical fibers, flame retardant materials, drug delivery and tissue engineering. Being pentavalent, phosphorous can exist in different chemical environments in these polymers which increase their versatility. In human biochemistry, phosphorous based compounds exert their functions both in soluble and insoluble form occurring as inorganic or as organophosphorous compounds. Specifically in case of biomacromolecules, phosphates are critical for functions of DNA, ATP, phosphoproteins, phospholipids, phosphoglycans and several coenzymes. Inspired by the role of phosphorous in functional biomacromolecules, design and synthesis of biomimetic materials are thus carried out by several authors to study macromolecular function or as substitutes in clinical tissue regeneration conditions. In addition, many regulatory signals of the body are controlled by phoshphorylation of key proteins present either in form of growth factors or matrix-bound scaffold proteins. This inspires works on synthesis of phospho-peptidomimetic amino acids for understanding key signaling pathways and this is extended to obtain molecules with potentially useful biological properties. Apart from above applications, phosphate groups bound to polymer backbones have also been demonstrated to improve function of osteoblast cells and augment performance of bone grafts. Despite the advantages of phosphate grafting, however, there is limited understanding on effect of degree of phosphorylation on macromolecular physicochemical and/or biological properties. Such investigations are necessary to effectively translate knowledge of macromolecular biochemistry into relevant clinical products since they directly influence processability of these polymers into suitable scaffold structures and control subsequent biological response. Amongst various techniques for fabrication of biomimetic scaffolds, nanofibrous scaffolds fabricated by electrospinning technique offer some special advantages in resembling the attributes of natural extracellular matrix. Understanding changes in physico-chemical properties of polymers as function of phosphorylation is therefore going to be crucial in development of nanofiber scaffolds based on phosphorylated polymers. The aim of the present work is to investigate the effect of phosphorous grafting on the electrospinning behavior of polymers with aim to obtain biomaterials for bone regeneration applications. For this purpose, phosphorylated derivatives of two polymers of widely different electrospinning behaviors were selected as starting materials. Poly(vinyl alcohol) is a conveniently electrospinnable polymer at different conditions and concentrations. On the other hand, electrospinning of chitosan backbone based polymers have been viewed as a critical challenge. The phosphorylated derivatives of these polymers were synthesized, characterized and electrospinning behavior of various solutions containing these derivatives was compared with electrospinning of pure poly (vinyl alcohol). In PVA, phosphorylation adversely impacted electrospinnability while in NMPC, higher phosphate content widened concentration range for nanofiber formation. Culture of MG-63 cells on electrospun nanofibers, revealed that degree of phosphate modification of a polymer significantly improves cell adhesion or osteoblast function of cultured cells. It is concluded that improvement of cell response parameters of nanofiber scaffolds can be attained as a function of controlled degree of phosphate grafting in polymeric biomaterials with implications for bone tissue engineering applications.

Keywords : bone regeneration, chitosan, electrospinning, phosphorylation
Conference Title : ICTERMA 2016 : International Conference on Tissue Engineering and Regenerative Medicine Applications
Conference Location : Amsterdam, Netherlands
Conference Dates : May 12-13, 2016